Simple way to test forced air house heating or cooling performance at a cost of $15 to $80.

But first here is the back story you should read…. **You may learn a lot…. I certainly did.**

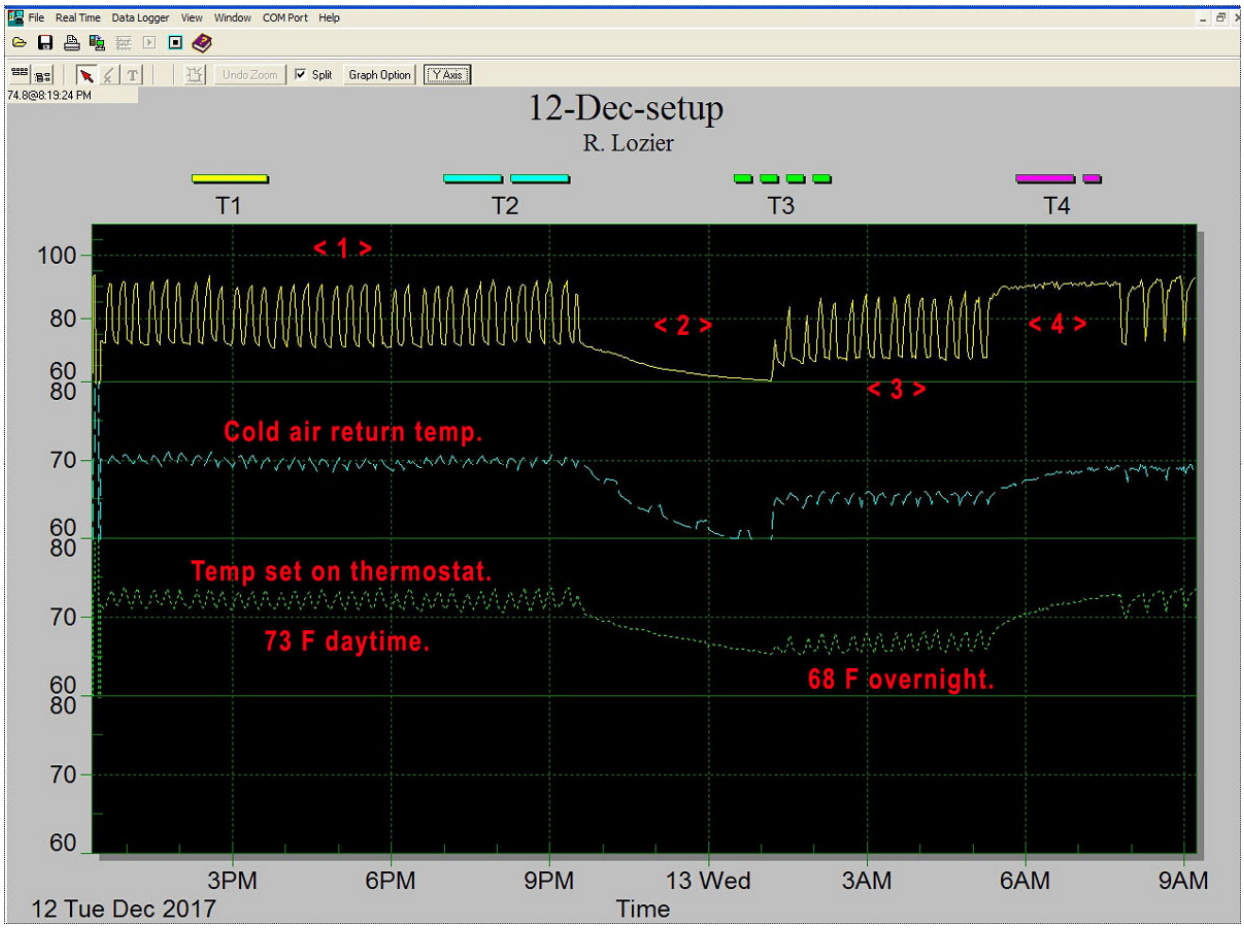
Here is the problem I faced…. My old pad mount gas pack HVAC unit was found to have a burned out heat exchanger, draft blower wheel and blower housing; too old to invest big bucks in a major repair; time to find contractors to quote a replacement system. I accepted a bid and the unit installation was almost complete when I came out to check on their progress. I read the nameplate on the new unit and was stopped in my tracks to read that the **BTU Output capacity** is only **80%** of the **BTU Output nameplate rating of the old unit.** %#@&! The sales representative who prepared the quote never told me that the "replacement" unit would have **20 % lower heating capacity**; he had accepted my statement that the heating and cooling capacity of my old unit proved adequate and I saw him make no measurements of my house or question me on construction details of my house that he might have used to yield new calculations indicating a lesser capacity unit would indeed prove adequate. He had prepared the quote on my dining room table and e-mailed it to me before he left.

So my dilemma was: How can I determine if the lower heating capacity of the new unit will adequately service the load of my 64 year old house that is certainly not up to modern standards for insulation and air leakage? **How can I back up my 'feelings of whether things are good or bad' with solid data I could present should a dispute arise?**

I am a retired electromechanical engineer with over 15 years direct experience in Compliance Testing. (The application of radio frequency, electrical, mechanical and environmental tests to new products in order to prove that they comply with industry and government standards here and abroad. I'm also a radio amateur. I thought I should be able to measure the operation of the furnace by automatically monitoring four things. (These monitored points will be equally valid for measuring performance of a cooling system.)

1. The temperature of the air coming out of one of the baseboard hot air registers. (Any register would do, not necessarily the register with the hottest air output.)
2. The temperature of the house air as it flows into my floor mounted cold air return in the central part of my house.
3. The temperature in a room where people congregate most; the sensor being placed out from the walls at least a foot or two and at a level of maybe four feet off the floor. (That ought to be a good choice regardless of how high the ceilings are in your house.)
4. The temperature outside my home. (Measured ideally 10 ft. or more from house walls and in a location where it will not receive direct sunlight; especially in early morning or late afternoon. (Note: Your house location may experience temperatures several degrees different from your local weather station readings. These temperature differences are most likely to be greatest when winds are calm and there are few clouds. Under winter conditions my property temp is about 2 to 3 degrees F higher than reported by the nearest weather station.)

I found a local radio amateur happy to loan me his four channel temperature data recorder with wired thermocouples. The computer software for the data recorder made it easy to graphically see how long the burner had to run at (presumably) full output before it could raise the thermostat set temperature from 68 F to 73 F **when the outside temperature was about 26 F**. On that morning, the burner was running continuously for **2 hours and 35 minutes** before switching to less than 100% duty cycle. **I was not happy.**



T1 = Measurement at a hot air register. T2 = Cold air return. T3 = Room temp.

< 1 > At the hot air register the burner is bringing register air up to about 93 F and is able to maintain the house temperature without having to run continuously during the daytime.

< 2 > The thermostat signals to allow the room temperature to drop 5 degrees F.

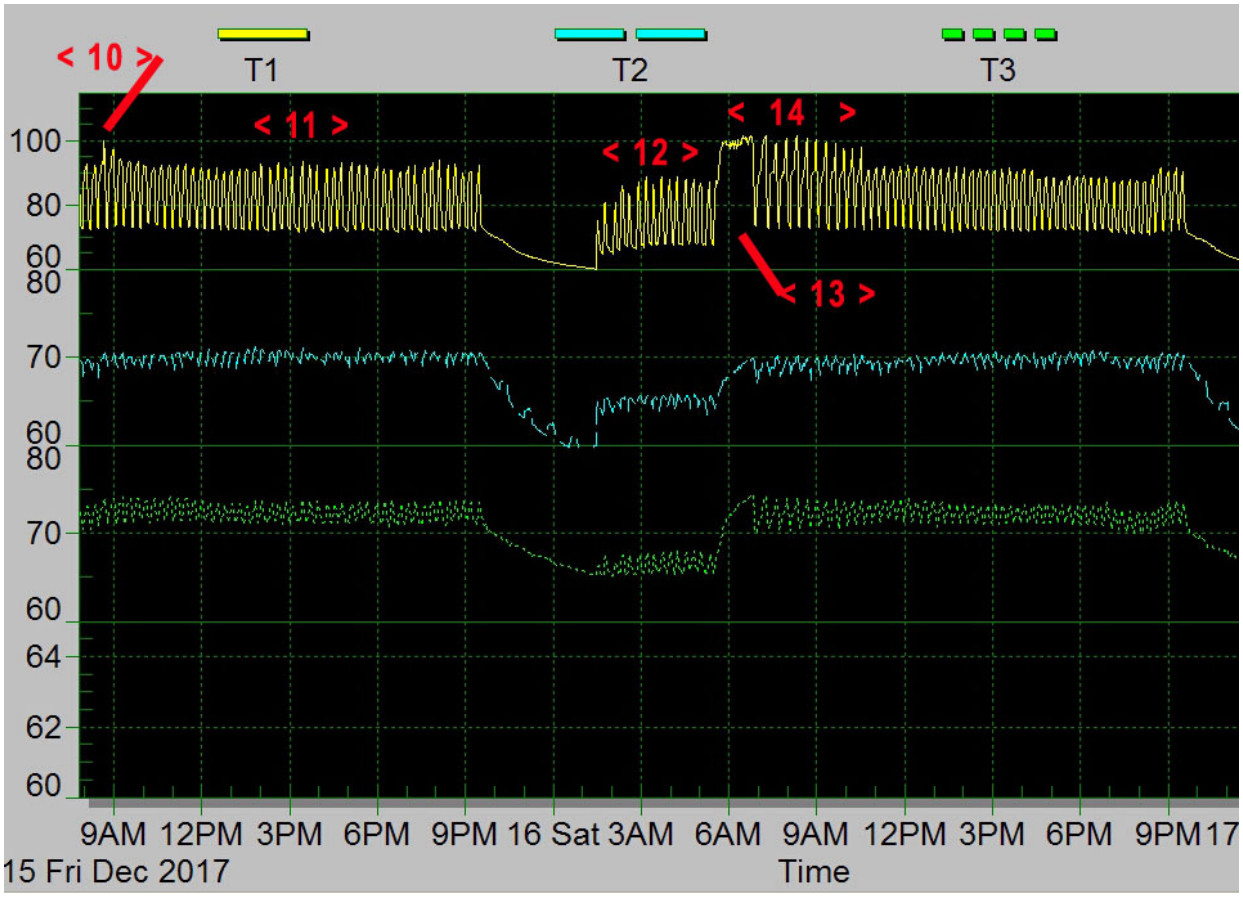
< 3 > The burner is able to maintain house temperature overnight without having to run continuously.

< 4 > The thermostat signals to raise the house temperature. The burner has to run continuously for about 2 hours and 35 minutes to bring the temperature to 73 F on a morning when the outside temperature was between 26 & 28 degrees F. **(Too long!)**

After consultation with the boss of the contractor business, he told me that their rule of thumb was that the furnace should be able to raise the house temperature about one degree F every 20 minutes when outside temperatures were in the mid 20s F. By that rule, the burner should have

run at 100% for just one hour and forty minutes. **Why did it take one hour longer?** The plots generated by the data logger software helped us figure out why.

As it turns out, the new furnace has a two stage gas burner. The contractor's installers had neglected to properly configure their replacement thermostat to work with a two stage burner. The net result was that the furnace was never operating at the full rated BTU output. He changed the thermostat setup to work with the two stage burner. After another day of monitoring on another similarly cold day, it was easy to see on the graph that the furnace could now raise the house temperature five degrees F in about one hour less time. It was also now easy to see how the thermostat would command the unit to switch from 1 stage to 2 stage operation. (You can see the average hot air temperature at the monitored duct drop 10 or so degrees F when the burner was operating at reduced output.) So with this configuration change I am inclined to think that the reduced system heating capacity may indeed still prove adequate for my house load.



< 10 > Contractor changes and test the proper thermostat settings for use with a two stage burner.
< 11 > Burner only needs to provide 93 F air at the register I was monitoring in order to maintain 73 F set point throughout the day.
< 12 > Burner still needs to only supply 93 F air over night.

< 13 > Note now that when the thermostat signals to raise the temperature 5 F, the burner only has to run for one hour and forty minutes at continuous operation because it is now delivering 100 F air at the measured register indicating the unit is operating at maximum output.
< 14 > Note that after about five hours the thermostat allows the burner to drop back to the lower BTU output capacity to maintain 73 F throughout the remainder of the day.

In addition, I realized that my measurement setup allowed me to also identify if the smaller air circulation blower of the new unit was adequate to prevent undesirable stratification of air in the rooms. That is where being able to compare the free air temperature in a room to that of the cold air return duct came into play. If there is a large temperature difference, say 4 or 5 degrees F or more, it would indicate inadequate blower capacity or something as simple as clogged furnace filters. In other homes I have seen really gross mold covered blower wheels, evaporator coils and collapsed or very dirty duct work that are significantly effecting room air circulation.

So how can Joe or Jill Homeowner do similar measurements on the cheap and without wires?

So you are not going to want to rent or borrow a $400 or more data logger and string thermocouple wiring around and outside your house. I've found there is a really low cost and easy way to gather much the same information and generate easy to read graphs of performance.

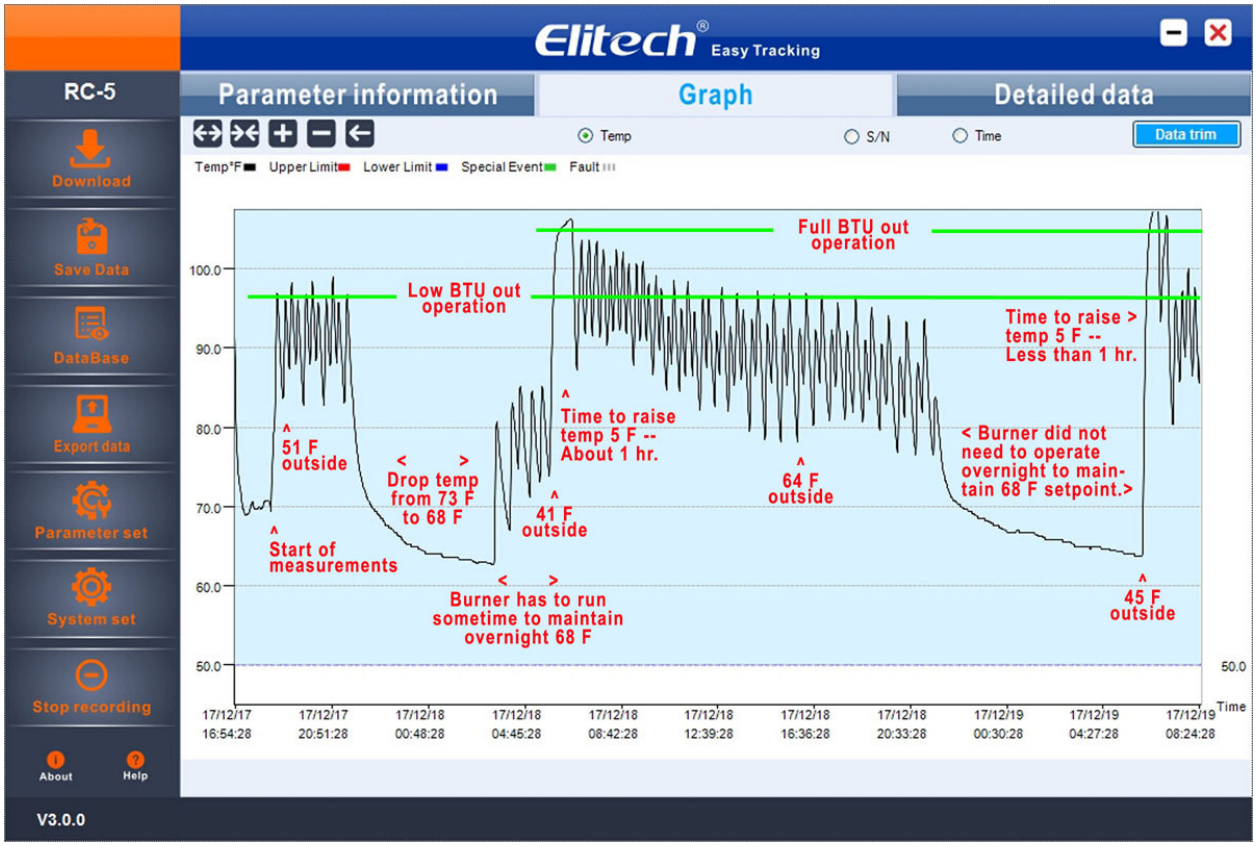
For over a decade now the food distribution and medical industry has used small and cheap single channel data recorders to verify the temperature exposure of shipments in transit or storage. They are used by the millions and can be found on eBay, Amazon, etc. **for $13 to $25, shipping included!**

The version I chose is the Elitech RC-5 Data Logger. Its built-in temperature sensor can make up to 32,000 measurements. Depending on how often the Logger is set to take a reading, you can record for from about 10 days to half a year powered by its own replaceable, common coin cell battery. It has a protected USB connector that simply plugs into your computer or laptop. Free software allows you to download the data stored and create plots. It really is easy.

So if you just want to know how long it takes your furnace or AC to change from one temperature to another on a given day, all you need is one of these loggers hanging over a hot air register and go on-line to find out your local weather station reported temperature conditions throughout the day.

See next page….

The traces look a little different but convey essentially the same information. The difference in appearance is because the 4 channel lab quality data logger is using plug-in thermocouple sensors that have very small mass and are in direct contact with the moving air. The little RC-5 Water Resistant Data Logger cannot respond as quickly to changes because its sensor is inside its plastic housing.



If you want to see room blower performance you will need two more to sense room temp (not just the temperature of a wall mounted thermostat in a hall way) and the cold air return. Even better if you have a fourth unit outside to refine the temperature actually experienced on your property. **Go for it!** At the time I made my purchase in December 2017, four sensors would cost **less than $60, shipping included**.

Think about it… If you have a homeowners group, you can loan out your set of data loggers so your neighbors can make their own **quantifiable** checks. The same for folks that gather at senior centers, or other fraternal groups. **I'm convinced this hard data made it much easier for me to negotiate with my contractor on rectifying problems.** As a bonus I now have reference data that I can use to compare future performance.